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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Steam Turbines

Part I

Stationary Outfits—Bearings

Note. An early number will contain Part II, devoted to Marine Turbines and Filtering Systems.

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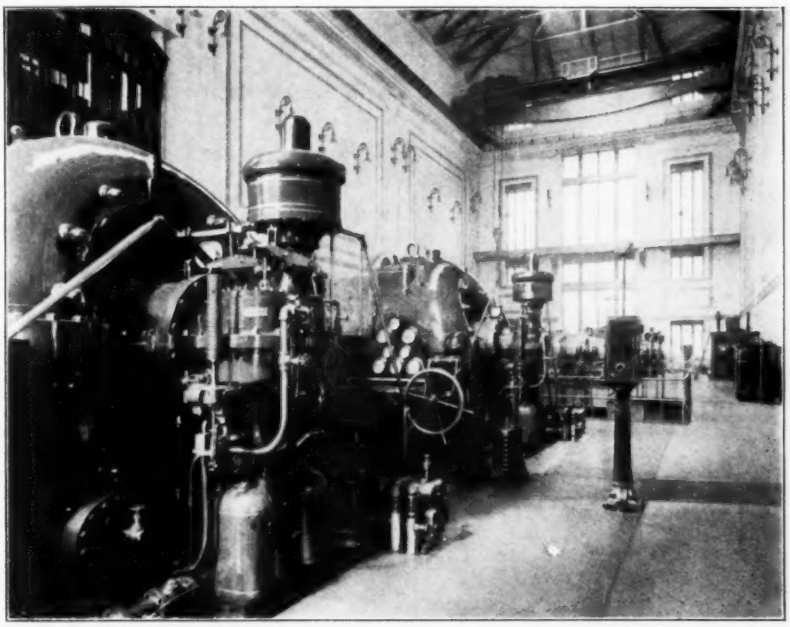


GENERAL VIEW 30,000 H. P. STEAM TURBINE OUTFIT, showing governor end with the necessary gauges, pumps, piping, etc.
Courtesy of the Westinghouse Electric Co.

Lubrication of Steam Turbines

Part 1. Stationary Outfits—Bearings

THE development of power from fuels by means of steam has been continually in the direction of larger or more powerful producing units, for experiments and experience has proved that as the units became larger the fuel consumption and cost of operation became smaller per unit of power developed. With the reciprocating steam engine this increase in size reached a limit beyond which it was impractical to go, as investment costs of machinery and space outweighed the saving brought about by the increased steam efficiency. But even in the most carefully constructed reciprocating engine, using quadruple expansion, the amount of power developed compared with that theo-

retically available in the fuel or even in the steam, is far from satisfactory, and efficiency is low.

The steam turbine by virtue of its small size per unit of power, compared with that of the reciprocating engine, is still capable of further increase in size in order to get more powerful single units. By it, also, a somewhat greater efficiency in the utilization of the available energy in the steam can be obtained, and the cost per unit of power developed can be decreased. But in order to get the many advantages of steam turbines they must be operated at speeds far above those of any reciprocating engine. These high speeds necessitate properly designed parts, exact alignment and careful balancing. In this article we shall indicate the principal features controlling the economical operation of steam turbines, paying particular attention to conditions affecting proper lubrication. We shall first consider land or stationary installations, and then see what other conditions must be met when turbines are placed on shipboard.

The history of the steam turbine begins over 2,000 years ago, when, between 120 and 150 B. C., Héro of Alexandria invented his classic toy the *Aeolipine*. This machine was the first attempt to utilize the energy of steam. Motion was derived from the reaction of steam escaping from short bent tubes causing a ball to rotate on its axis after the manner of the common lawn sprinkler, or pin wheel. After the appearance of this elementary engine, over 17 centuries elapsed before any effort in a similar direction was made.

In 1629 Giovannia Branca, an Italian, devised a steam wheel acting by the impulse of a steam jet on blades, or veins, on the circumference of a wheel. This stands as the practical ancestor of the modern steam turbine. This, however, was soon forgotten and was followed by the efforts of Savery, Papin, Newcommen, and finally Watt, to apply the energy of steam to useful work. All these efforts resulted in the reciprocating type of engine which is so well known to-day.

The works of Héro and Branca were followed from time to time with the object of obtaining rotary motion direct from the action of steam. Not until the last quarter of the nineteenth century, due to the ingenuity and perseverance of Parsons and DeLaval was the turbine a commercial success. To these names a number of others might be added at the present time, who have helped to bring the steam turbine to the place it occupies to-day.

Advantages of Turbines

In the reciprocating type of steam engine, the steam under pressure expands against a piston which transmits the power to a rotating shaft. To get the most value out of steam under pressure the expansion should be adiabatic, that is, all the energy expended in pushing the piston back should come from the steam itself and none be given to or taken from the cylinder walls in the form of heat. But steam in expanding becomes cooler, and in actual practice heat will be given to the cylinder walls in the first part of the stroke and taken from it in the last part. Unless the steam is superheated there will be a condensation on the cylinder walls, entailing a loss of power. When high steam pressures and temperatures are available it is found most practical to make the expansion of steam take place in three or four stages instead of one. This expansion in stages partially eliminates some cylinder troubles and gives higher heat efficiency, but its application is limited by the fact that increasing the number of cylinders beyond four, causes such an increased cost in operation as to more than counterbalance any increase in heat efficiency thereby obtained.

In the steam turbine instead of utilizing its expansion force directly, the steam is first allowed to expand without doing work; thereby changing its potential or latent expansion energy into kinetic or velocity energy. The steam at high velocity is then caused to impinge on small buckets or blades so designed and arranged around the circumference of a wheel as to absorb this kinetic energy and transform it into rotational energy around the shaft to which the revolving wheel is attached. As in the case of reciprocating engines, this expansion of steam and absorption of the resultant energy in the revolving blades

can be done most efficiently in a number of stages. But in case of turbines this increase in the number of stages can be done with little increase of operating cost, and large modern turbines using high pressure superheated steam use a large number of successive expansions in order to get the maximum economical result.

Some of the advantages of the steam turbine are:

1. Simplicity—Ease of attendance and repairs.
2. Compactness.
3. Relatively light weight.
4. Lack of vibration.
5. Close speed regulation — Uniform running.
6. Small friction.
7. No loss from cylinder condensation.
8. Adaptability to the use of highly superheated steam.

Types of Turbines

There are, in general, three types of turbines in commercial use: The impulse, the velocity, and reaction types. In the simple impulse type the total pressure drop takes place in a single set of nozzles, and the jets act on a single set of blades. In the multiple impulse type the expansion takes place in a succession of nozzles placed between each set of blades, the expansion in each nozzle being so arranged as to transform most economically the maximum amount of steam energy into revolving energy. In the velocity type the kinetic energy from a single set of jets is absorbed in a number of rotating discs instead of one, the steam being properly directed by stationary blades between each stage. In the reaction type the steam expands in the rotating blades, and the disc moves by virtue of the reaction forces. In the first two types there is practically no pressure drop across a set of revolving blades. The machines used in practice, as the De Laval, Curtis, Parsons, etc., while illustrating these effects, are usually constructed so as to combine more than one or all of these principles.

Without going into any discussion as to reasons, it can be stated definitely that in order to get the maximum value out of the steam the lineal velocity of the blades receiving the steam energy must be high. This requires that the rotating discs shall either be large in diameter or turn at a high speed. The diameter of the disc is limited mechanically, as large diameter discs are difficult to construct, and costly. As even when not operating under the highest efficiency, turbines usually rotate from 2,000 to 10,000 R. P. M., these high speeds demand the most carefully designed bearings, the very best lubrication system, and highest grade of lubricant. When a slowly moving surface is insufficiently lubricated it wears very slowly, and a long time is required before it becomes hot. In fact, the generated heat of friction may be conducted away so rapidly that the bearing never gets perceptibly hot. It may be wearing away with a loss of power, and yet the trouble not be noticed until the damage is done. When the high speed bearing, with its close clearance, is not properly constructed or lubricated, it heats very rapidly and may be entirely destroyed before the trouble is discovered or can be corrected.

DETAILED VIEW OF BLADES, showing method of holding in position.

Courtesy of the Westinghouse Electric Co.

Hence the very best methods of applying the lubricant, and the finest quality of material, are essential for the steam turbine.

For the purpose of analyzing lubricating requirements, steam turbines may be divided into the following general classes:

1. Horizontal or vertical.
2. Direct drive or reduction gear drive.
3. Stationary or marine.

The majority of steam turbines, especially the smaller units, are of the horizontal direct drive stationary type, though many of the latest large machines drive through gears. This latter construction is especially used in the case of marine outfits as the speed is determined by the speed of the propeller. We shall study first the lubrication of the horizontal direct drive stationary type, and then consider what changes or further details are required by the other types.

Bearings

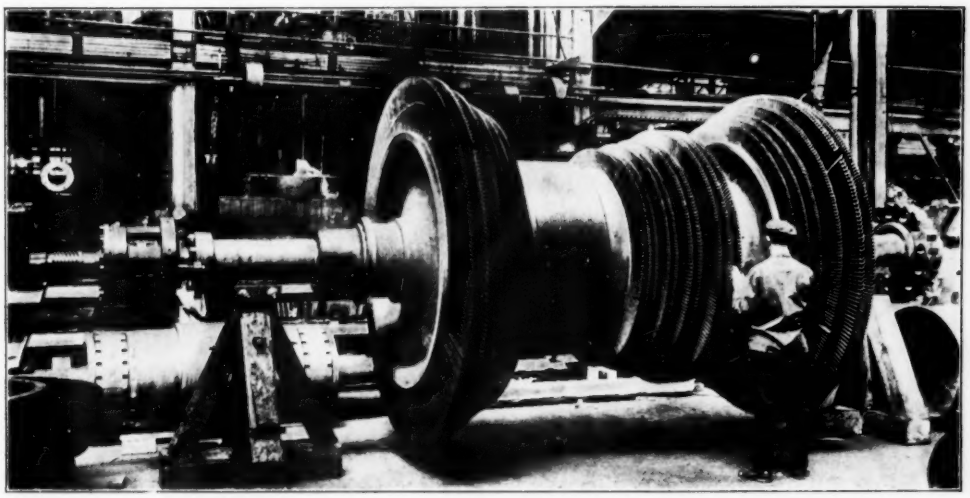
The fundamental purpose of all oiling systems is to reduce the friction loss of the bearings to a minimum with lowest cost of lubrication and of operation. A bearing consists of two parts, the journal and the housing. For practical construction and renewal reasons the housing is divided into several parts. These differ with the design, but in all cases there are the bearing pieces or "brasses" which surround the journal and supply the bearing or sliding surface for the journal. The bearing pieces may either be of brass, or babbitt metal. The larger units generally use babbitted bearings. Metallic friction between the journal and the bearing pieces is reduced or eliminated by providing a film of lubricant between these relatively moving parts, and the degree of perfection of lubrication attained will depend on how low a frictional resistance can be obtained. A perfect lubricating system will prevent all metallic friction and introduce only a minimum oil friction, as generally speaking metallic friction is greater than oil friction.

Metallic Friction

Metallic surfaces, no matter how well polished, are microscopically rough. When two such surfaces are rubbed together, the small projections and depressions tend to interlock. This can only be overcome by a tearing away of the projections, compressing or pushing them aside, or by the separation of the sliding surfaces sufficiently by a lubricant to allow the projections to pass each other. When the sliding surfaces are thus covered with a lubricant, in order that the projections may interlock, the lubricant must be pushed from the depressions and from around the projections. While liquids are mobile and will work out gradually from between two surfaces under pressure, yet the resistance to flow, or viscosity of the liquid, hinders the action and considerable time may elapse before the surfaces come into contact.

When oil is between two surfaces they will not, under ordinary conditions, be forced into as close contact as if the surfaces are dry; even if a long time is allowed for the action to take place. This is due to the property of most liquids to adhere to or to "wet" solids. This action is very strong indeed in the case of oils with metals, and is one of the governing factors which makes them such excellent lubricants. It is very difficult to rub all the oil from a metal surface unless heated, as the oil seems to get into the pores of the metal and refuses to be displaced.

This adhesive property of oil, however, although assisting in lubrication, is not sufficient in the case of turbines to maintain a film of oil between the rotating journal and the bearing, and prevent metallic contact. The maintenance of a film will depend primarily on the character of surface, load per square inch, rubbing speed, clearance, and viscosity of the oil at the temperature of the bearing. Smooth surfaces can operate with a less clearance than rough ones, and hence will require a less thickness of oil film to keep them out of contact. An increase in load on a bearing naturally tends to force the oil out and the parts nearer together, and, other things being equal, when a bearing is subjected to a heavy



ASSEMBLY OF BLADES IN ROTATING PORTION OF STEAM TURBINE. In this type the steam acts upon the smaller blades at the center, towards the right until partially expanded when the volume of steam is divided, part acting on the blades at the extreme right and part in the opposite direction on the blades at the extreme left. This balances to a considerable degree the end thrust on the rotating portion.

Courtesy of the Westinghouse Electric Co.

load, a higher viscosity oil is necessary to keep the parts out of contact than if the load is light.

Effect of Speed

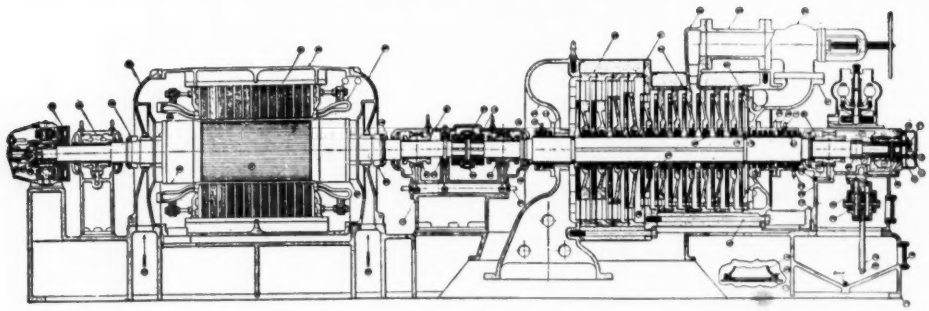
The rubbing speed affects the amount of oil dragged into, or out, of a bearing. As previously stated, a film of oil adheres tenaciously to the revolving journal, and on account of the viscosity of the oil the adjacent layers to that adhering to the metal are dragged with it. These are resisted from entering the clearance space by the fact that the oil already there is being forced out by the weight of the bearing. This latter force is practically a constant, while the force dragging the oil with the journal is proportional both to rubbing speed and viscosity of the oil. It is thus seen that at high rubbing speeds an oil of less viscosity is required in order to maintain an oil film against the expulsion force than at low speeds.

Clearance Space

The design of the bearing greatly influences the maintenance of an oil film. As mentioned above, a revolving journal drags the oil into the clearance space. This is assisted by having this clearance space somewhat larger at the point of entrance of the oil than at the other parts of the bearings. This forms a wedge of oil, the oil entering at the thick part of the wedge and going out the other thin edges. Analysis has shown that the pressure in the oil film varies in different parts, the least pressure existing at the top and sides of the bearing. It is therefore necessary that the oil be introduced at these points of low pressure. The clearance space allowed in most turbine bearings is 1/1000 inch for each one inch diameter of journal. In modern high speed bearings using light oils, it has been found that no oil grooves should be used as they may allow the loss of the built up oil pressure in the bearings space. In some bearings, however, oil grooves are still used.

Fluid Friction

We have discussed, above, the elimination of metallic friction by the interposition of an oil film. This does not entirely do away with friction, as the oil itself presents a resistance which may become quite considerable. As we have previously seen, oil adheres quite tenaciously to metal surfaces. Therefore, in sliding one surface over another separated by



Cross section through direct connected steam turbine unit, showing turbine, generator, exciter, governor, etc.
Courtesy of Kerr Turbine Company

an oil film, the sliding takes place in the oil body and not between the oil and metal. The viscosity of the oil resists this shift in the oil film or, practically speaking, the sliding of two oil films over each other, and energy must be expended to bring it about. The amount of energy required to turn a journal in a bearing, if the clearances do not change, is proportional to the viscosity of the oil and the speed of rotation. It can readily be seen, therefore, that while at low speed the heat generated may be small, at the high speed necessary in turbines the heat due to friction may be very great. This is accentuated by the fact that for many reasons it is desirable to have small clearance spaces, and, by the nature of viscosity, the friction resistance in the oil body is inversely proportional to the thickness of the film. This frictional heat, therefore, increases with decreasing thickness of film.

Cooling Effect of Oil

This heat is generated so rapidly that it is impossible for it to be radiated or conducted away as quickly as produced, and it is one of the principal functions of the oil to carry away this heat. This is very essential as the viscosity, and hence supporting power, of the oil drops rapidly with temperature rise, and may quickly reach a point where the oil ceases to keep the metal surfaces apart and there will be sizing. It is customary, therefore, to use a large quantity of oil, forcing it into the bearing under pressure. Part of the oil passes through the clearance space while the excess acts as a cooling agent before draining back into the sump tank. The top of the bearing brasses may be slotted so as to allow the oil to get at the journal and keep it cool. The bottom brass is not so easily cooled as only oil in the clearance space comes in contact with it, and this oil is very hot. The cooling here is practically all by conduction to some surface over which the main body of oil is flowing, unless the oil is forced through the clearance space.

The temperature of the oil into and out of a bearing will vary according to the amount of oil being flooded through it, but often shows a rise of 15° to 20° F. When it is considered that this heat, which is distributed in a large volume of oil, is in most cases produced in only that small portion passing through the clearance space, it is evident that the temperature of the oil film may be exceedingly high, and only the best grade of oil will withstand it.

To the above heat must be added the heat conducted along the shaft and housing from the turbine. Some bearings may be water cooled to cut this down but in most cases the oil is required to carry off this heat. Oil temperatures of 175°–185° F. are not unusual. This high general temperature, however, need not necessarily cause any alarm provided the rise in the oil film is not excessive. The matter of temperature depends on the design of bearing and viscosity and volume of the oil. As previously stated, oils decrease rapidly in viscosity as the temperature rises, and the value of an oil as a lubricant will depend on the viscosity at the working temperature and not on its rated viscosity usually taken at 100° F. In fact, if the oil is also required to work on gears, it may be necessary to heat it so that its viscosity is sufficiently reduced to operate satisfactorily in the bearings.

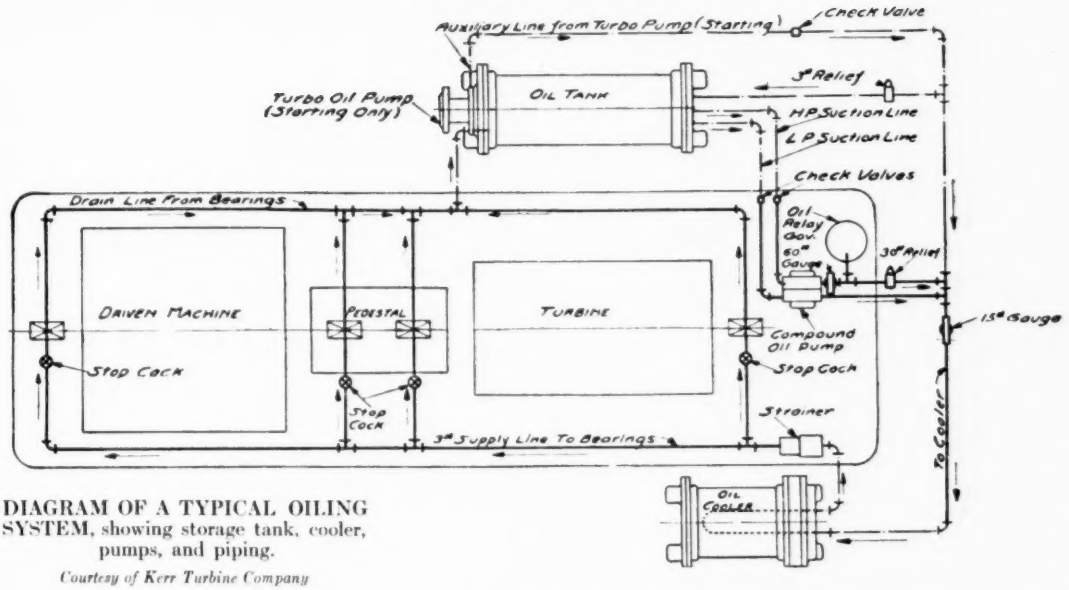


DIAGRAM OF A TYPICAL OILING SYSTEM, showing storage tank, cooler, pumps, and piping.

Courtesy of Kerr Turbine Company

Viscosity

There are a number of formulas purporting to give the viscosity of an oil required to operate in a turbine bearing of stated dimensions. Some of these may give a general idea, but it is unsafe to depend too much upon them without making some experiments on the actual piece of apparatus under consideration. While in many cases an oil having a viscosity of about 150″ Saybolt at 100° F. may operate satisfactorily, slight variations in bearing clearances or alignment, and different speeds and temperatures may entirely alter the requirements. It is axiomatic, however, that it is better to have an oil of too high viscosity than one of too low a value. The more viscous oil will cause higher fluid friction and consequently a higher bearing temperature, but this condition will soon be partially corrected as the viscosity will go down with rising temperature, reducing the friction until a working equilibrium is reached, and the temperature will not rise further. On the other hand, if the viscosity is too low there may be metallic rubbing with a rise in temperature which, further reducing the viscosity, will decrease the bearing power of the oil and sizing will soon result. This is an unstable condition which is very undesirable and apt to be overlooked when too much attention is paid to getting the oil with the lowest viscosity that will work under the normal operating temperature.

There are a number of other factors besides viscosity which influence the choice of an oil for a turbine bearing, and these will now be considered.

Evaporation

The turbine oiling system is usually a tightly enclosed affair, as free from oil leaks as it is possible for mechanics to make, consequently there is very little loss of oil and the initial charge lasts a long time. Any petroleum oil when agitated in the presence of air at the temperatures of the bearing will vaporize to a certain extent, depending on the characteristics of the oil. Some of the lighter portions of the oil will be driven off, no matter how tightly the system may be enclosed, and the remainder of the oil will slowly thicken and increase its viscosity. Properly refined oils having a minimum evaporation will last a long time without any serious increase in viscosity due to this cause, and there are records of turbines operating for years on one charge of oil, only a small amount being added from time to time to make up for evaporation and leakage. The leaving of a single charge of oil in a turbine for a long time without some sort of attention is not to be recommended, however.

Decomposition

Perhaps the greatest effect of the high bearing film temperature on an oil is a slow decomposition and possible oxidation. All petroleum oils, when subjected to high temperatures, slowly change their composition, and if air is present there may be a slight oxidation. This results in an admixture of undesirable compounds that may cause gumming, emulsification, and under extreme conditions, and especially if water is present, there may be a slight corrosion. This latter effect is, however, largely overdrawn and almost all cases of supposed corrosion can be traced to other causes. The petroleum acids which may be found in small quantities are quite inactive, and even in the presence of water must be quite concentrated to have any corrosive effect.

This slow breaking down usually manifests itself by a darkening of the oils, which, however, may proceed for a long time before the lubricating qualities of the oil will be seriously affected. The pale oils on account of their light color show this darkening more rapidly than dark oils, but are in reality not decomposed any more than, if as much as, the red oils.

Emulsification

The most important effect of the gradual breaking down of oils is the formation of oil bodies which emulsify with water. Highly refined oils of proper character when shaken with water will separate from the water very quickly if allowed to stand quietly a few seconds. Water, in practice, cannot be kept out of the turbine oiling system. It may come from leaks in the bearing cooling water jackets or in the oil cooler pipes, from steam leaking through the stuffing boxes, from moist air drawn into the system, from cooling or steam heating coils in the filtering system, etc. If the oiling system has been properly designed and is of ample capacity, when a suitable oil is used, all of the entrained water will separate from the oil in the reservoir and may be drained off, but if the amount of oil in the system is too small, requiring rapid circulation, there is not enough time for the water to separate and it is carried with the oil to the bearings. The quality of two oils being the same, the oil with the lower viscosity and the lower specific gravity will separate from water the more readily.

When oils are used which are not properly refined and filtered for this purpose, the continued agitation of the oil and entrained water will form an emulsion. The oil becomes thickened and picks up and holds foreign particles getting into the system which act as abrasives when the oil is supplied to the bearings. As the oil becomes thicker and thicker, it finally reaches a point where it will not flow properly through the oil pipes and bearing grooves, and bearings, not receiving proper lubrication, become hot and wear.

Naturally the best means of preventing emulsion is not to allow water or steam into the system. As this is practically impossible, a place must be arranged in the filtering system where the oil can come to comparative rest, and the water allowed to settle out. It may be advisable to heat the oil so as to allow this settling to take place more rapidly. If the amount of oil used in a system is large and the emulsion small, it is not necessary to treat the whole quantity of oil each time it passes through the lubricating cycle, but a portion may be continually by-passed, settled and then passed back to the main supply.

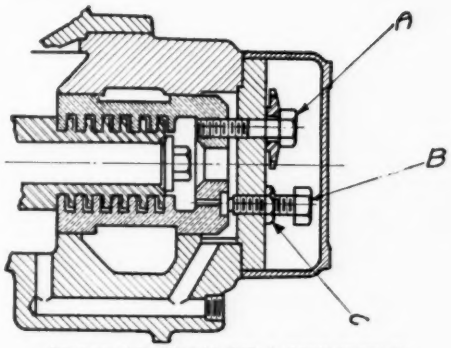
Any oil to be suitable for turbine use must have a high resistance to emulsification. This quality depends on the character of the oil and the treatment which it has undergone in refining. Oils suitable for turbine use will separate very quickly from hot water and leave the water only slightly cloudy. Oil can be compared for emulsibility by shaking equal quantities with equal quantities of water and allowing to stand. In this connection, however, it must be remembered that oils with high viscosities separate more slowly than those with low viscosities.

Akin to the emulsifying action of oil in a turbine system is foaming. This manifests itself in an overflowing of the reservoir or at some other open vent. It is caused by the presence of a temporary emulsion which is formed more rapidly by some agitating action

than it can settle out. This emulsion may either be a mixture of oil and water or oil and air. It naturally is more prone to form with heavy viscous oils than with the more fluid ones. The remedy is an ample sized drain line, and a settling tank of good proportions, heated if necessary.

Sludge

When some oils break down under heat and pressure, there may be formed certain types of petroleum compounds which are more or less insoluble in the oil mass. These compounds usually settle out in the settling tank in the form of a sludge, or are filtered out by the filters; but if there are any pockets in the lubricating lines they are apt to settle there, especially if the settling or filtering units are not efficiently operated. If the oil pumps are always run at the same speed, and no large amounts of new oil are added, this settling of the gummy products will not do much harm provided at stated intervals the whole system is cleaned. But on the other hand, if for any reason the pumps are speeded up or an oil of a different character is added to the system, this gummy sludge may become dislodged or dissolved loose from its resting place and cause no end of trouble in the system. If it is surmised that the sludging is taking place, it is better to remove a little oil at a time, using it for other purposes and replace by fresh oil. Or if the oil seems to be all right otherwise, the batch removed may be returned after cleaning.

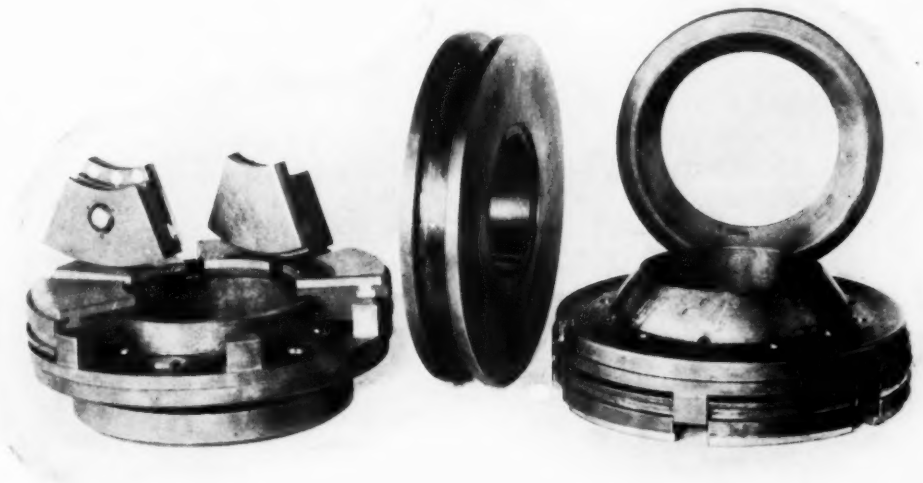


CROSS SECTION OF A MULTIPLE RING THRUST BLOCK. This type needs particular care in lubricating.
Courtesy of Kerr Turbine Company

Thrust Bearings

We have considered above the lubrication of the main turbine bearings of horizontal units.

In many of the large modern turbine outfits the units are vertical, and the weight is carried on oil pressure or Kingsbury thrust bearings. These were discussed in the December issue of



VIEW OF A DIS-ASSEMBLED KINGSBURY BEARING. This type of bearing will take thrust in either direction, the shaft being attached to the central bearing ring. Notice bearing shoes and pins upon which they rest.

Courtesy of Kerr Turbine Company

LUBRICATION under hydraulic turbines. Briefly it may be said that the oil in these is not usually subjected to any heat other than that generated in the oil film, and practically all the oil is forced through the film. Under these conditions a high-grade oil lasts for a long time and gives little trouble. A highly refined oil of 180″–200″ Saybolt viscosity at 100° F., which is non-emulsifying, will operate satisfactorily. This holds equally true for Kingsbury thrust bearings used in the Marine service.

Foundations

One of the most essential items in the installation and operation of steam turbines is the foundation on which the unit rests. When it is considered how small are the bearing clearances allowed, it is evident that any sagging or shifting due to strains or improper setting up may so change the alignment as to cause the bearings to bind and run hot. The foundation must be absolutely rigid with smooth surface for attaching the base of the unit. In setting up the machine base, means should be provided for compensating for any unequal metal expansion due to unequal heating. In addition flexible couplings may be provided between the turbine and driven apparatus, but these should be in the nature of an extra precaution and not as an essential detail. The parts of the unit should run in alignment without the coupling. Couplings should be lubricated.

Another feature which must be considered in any oiling system is the oil operated governor. In some types these become quite warm, and the oil should be kept free from gum or emulsions. They usually operate under pressure of oil, the excess draining into the sump tank.

Specifications

In regard to the proper specifications for an oil that will lubricate turbine bearings at a minimum cost of operation, it is difficult to make a definite statement that will hold in all cases. It can be stated, however, that:

1. It should be a highly refined mineral oil without any mixture of fatty oil.

2. It should be straight run and show a low evaporation loss when heated to 175° F.

3. It should resist emulsification with water to as high a degree as is practical to manufacture. There is some difference of opinion as to how a standard emulsification test should be carried out, but a rough idea can be made by shaking equal quantities of oil and water vigorously and watching how quickly they separate. A good oil should separate in a few seconds without any pronounced collar of unseparated emulsion.

4. The Flash Point should be over 320° or sufficiently high as to indicate a low evaporation percentage.

5. Acidity: Less than .07 milligram potassium hydroxide should be required to neutralize 1 gram oil.

6. Viscosity: If bearing clearance spaces are uniform in thickness, alignment perfect, and speed high, an oil of 150″ Saybolt viscosity will probably operate satisfactorily provided the temperatures do not go over 175° F. But as we have stated previously, alignment and clearance spaces are rarely ever perfect and if metallic contact takes place to any extent due to unusual circumstances, the heating thereby caused will result in the lowering of the viscosity in the rubbing film and sizing will soon follow. We, therefore, feel safer in recommending an oil of 180″–200″ viscosity at 100° F., believing that a slight extra heating of a bearing is better than a burned out one. In large turbines it may be necessary to go to higher viscosities but designers usually keep the bearing unit pressures low enough to allow of the 180″–200″ oil being used.

Summary

We have considered above the principles underlying the operation of steam turbines and paid particular attention to the lubrication of the bearings. In a later article we shall consider the lubrication of reduction gears, and discuss purifying and operating systems, particularly as applied to marine outfits.

Improper Alignment of Bearing Cap

Not long ago one of our engineers was instructed to call at a large sawmill that was using our Canopus oil in a gravity feed circulating system on a 350 H. P. Corliss Engine. It developed upon investigation that neither this oil nor any other oil that the Plant Engineer had used had been able to keep the generator bearing of the engine from running hot. It required quite a little diplomacy to get the Plant Engineer to admit that the bearing cap had never been removed to his knowledge, and to persuade him to take it off during a noon period. When the lock nuts that held down the bearing cap on one side were removed, the cap raised up about ¼ of an inch. This indicated that too many liners were under one side of the cap which also held the babbitt metal and not enough under the other, so that one side of the cap was riding on the shaft. When the liners were properly placed under the cap the trouble ceased.

This tendency of some engineers to jump at conclusions and not investigate the conditions thoroughly has given many an oil an undeserved "black-eye."

Don't Always Blame The Oil

An engineer of this company was recently instructed to investigate a complaint of a customer that the last barrel of Nabob oil received contained lint to such a degree as to stop up the screen of the automatic circulating system in the plant.

Upon arriving at the plant the engineer went to the oil house and pumped some of the oil from the half-barrel tank where it was stored. On allowing it to run through a fine mesh screen, the latter soon choked up with lint and fine fuzz. It was found upon investigation that the oil had arrived in a steel drum. Knowing the care taken in filling the drums at the Company's plant the engineer was positive that the trouble was not here, though the oil had been dumped and he had no proof of this fact. Inquiries developed the fact that the oil tank had been especially cleaned before the oil was put into it, the engineer in charge doing it himself. Upon examination of the pump, however, a piece of waste was found under the check valve at the suction of the pump. When this was removed, and the pump cleaned, no lint was observed in the oil passing through the finest screen obtainable.

Importance of Proper Designing of Bearing Feed

Some time ago one of our engineers was sent to investigate a complaint that had been received to the effect that Texaco Crater Compound was wearing out and had become so thin that it would not operate satisfactorily on a set of Falk Reduction Gears. This installation was one of the largest reduction gear drives in the middle west, and it was very essential that the plant should operate efficiently.

Upon entering the mill there was found to be about 4 inches of a mixture of Crater Compound and oil around the base of the machine, and the Master Mechanic informed the engineer that he was using 125 gallons of oil and a half barrel of Crater Compound a week, a quantity which was way out of proportion to that which should be required. The unit was a standard one with ring oiled bearings, and some one had the happy thought of equipping it with a gravity feed circulating system, and had placed the supply tank about 20 feet above the unit, using ⅜ inch pipe with six 90-degree turns in it to take care of the overflow. The result was that there was an excess oil pressure in the bearings, which forced the oil out of

bearings into the gear case where it became mixed with the Crater Compound, killing its adhesiveness and causing it to drain off from the gears. As this made the Crater Compound quite fluid, with a tendency to run out from the gear case, the case had been plugged tight so as to retain it, with the result that the Crater was not of proper consistency to operate with satisfaction.

The condition was remedied by cutting out the circulating system so that there was no excess pressure of oil to force it into the gear case. The result was that the Crater Compound then worked efficiently with the gears, and its consumption and that of the oil was cut down to 100 pounds of Crater and 10 gallons of oil each month, instead of 900 pounds of Crater and 500 gallons of oil. This goes to show that while lubricating systems are very efficient they must be installed correctly and with full knowledge of all other factors involved in the lubricating problem.

Another similar complaint of Crater Compound becoming mixed with oil from the bearings, which in this case were ring oiled, was corrected by supplying the oiler with a flash light. This was done so that he could give the bearing only the quantity of oil that was needed instead of flooding it. Previously he could not see the amount of oil in the bearing on account of the darkness at its location and so gave it plenty of oil for safety sake.

Tight Glands Not Always The Best Policy

One of our engineers, while operating in an electric power plant, experienced quite a little annoyance one day when he noticed that the piston of one of his dry air pumps, which was maintaining a vacuum on an 8,000 square feet condenser, had started to strike on the head end of the cylinder. As this air pump was in first class condition and no changes in adjustment had been recently made, he was somewhat at a loss to determine the reason why this trouble had suddenly appeared. It was impossible to shut down the unit, as this would have caused a suspension of service on 100 miles of electric railway, but something had to be done, for the pump promised to tear itself to pieces if the trouble was not corrected.

After some difficulty, the engineer got in communication with another engineer who had been in charge of the plant on the previous shift. The only information which was obtained as to any change that had been made in this piece of apparatus was that the packing gland on the piston rod had developed quite a steam leak, and it had been necessary to set up on it. This did not seem of value, but upon observing the piston rod and packing gland closely it was noted that the packing was charred and was sending forth smoke which, on casual examination, would be taken as steam. The packing gland was then eased off and a copious supply of cylinder oil was applied to the rod. In about 7 or 8 minutes the knocking ceased, and there was no further trouble.

The cause of this trouble was finally determined to be that on account of the small clearance between the piston and the cylinder head of the air pump, sufficient expansion had been brought about in the piston rod—this was a straight line outfit—by the heating at the gland to cause it to expand and cut down the clearance space to zero. This, of course, was corrected by doing away with the frictional heat generated at the gland, through the use of cylinder oil. This may be quite a freak cause of trouble but we think it worth mentioning as other engineers may have similar difficulty.

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Steam Turbine Lubrication

In order to lubricate successfully there are four things a turbine oil *must not do*

1. **It must not decompose.**
2. **It must not emulsify.**
3. **It must not evaporate excessively.**
4. **It must not cause corrosion.**

Turbines lubricated with Texaco Turbine Oils are not subject to these undesirable defects for the following reasons:

a. Texaco Turbine Oils do not decompose over long periods of use. They are pure mineral oils and great care has been taken to keep them free from any materials which might oxidize or might precipitate tarry sludge when exposed to heat and pressure.

b. Texaco Turbine Oils do not form emulsions. They are so highly refined that there are no unsaturated hydrocarbons left in them which will hold water in suspension. They free themselves readily from any water or moisture which may enter the system.

c. Texaco Turbine Oils are so carefully refined in the process of manufacture that they contain a minimum of light ends, and have a minimum evaporation under high operating conditions.

d. They will not cause corrosion of shafts and bearings as the chemically active ingredients which appear in ordinary oils are removed or completely neutralized.

The turbine using Texaco Turbine Oil is assured of a constant stream of clean, cooling oil by virtue of entire freedom from clogged oil pipes. Texaco Turbine Oils are readily and rapidly filtered.

Likewise, because of negligible evaporation and the absence of decomposition, only a very little additional oil is needed to make up the small natural losses.

The following Texaco Turbine Oils are recommended:

STATIONARY TURBINES

Ring Oiler Bearings, *Normal conditions*	TEXACO REGAL OIL
Ring Oiler Bearings, *Exposed to high temperatures*	TEXACO ALCAID OIL
Circulating Oiling Systems, *Direct drive*	TEXACO REGAL OIL
Circulating Oiling Systems, *Reduction geared*	TEXACO ALCAID OIL

MARINE TURBINES

Normal conditions	TEXACO MARINE TURBINE OIL "M"
Having high pressure Reduction Gears such as the Falk Type	TEXACO MARINE TURBINE OIL "H"

The Texas Company

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The Easy Pour Can to the Rescue

A Tale of

A DARK NIGHT—30 MILES FROM NOWHERE

(Taken from a Salesman's Report)

"In closing, will relate an incident which McWilliams the night man told me. A Taxicab driver fell for his line of talk on the Easy Pour and said—'I'll take one, I don't know what the Heck for, but I'll let you make a sale anyhow.' About two nights later he was on a call about 30 miles out on Long Island and somebody had forgotten to fill up his oil tank. It was about 2 a. m. It looked like a long wait for daylight. Then he remembered! *Oh Joy!* The Easy Pour was resting snugly under the seat. Those two quarts of Texaco Motor Oil saved the day. Later, when he called again, he was profuse in his remarks to McWilliams for selling him that life saver Easy Pour Can; and that is only what might happen to any of the five million car drivers, a great many of whom do not carry any spare oil."

MORAL

An emergency like this proves that the Texaco Easy Pour Can *is as necessary as a spare tire—as important as a fire extinguisher on your car. Tuck an* Easy Pour Can *under the seat and you will not be stuck on the road for want of oil.*

THE TEXAS COMPANY, Dept. H., 17 Battery Pl., New York City

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